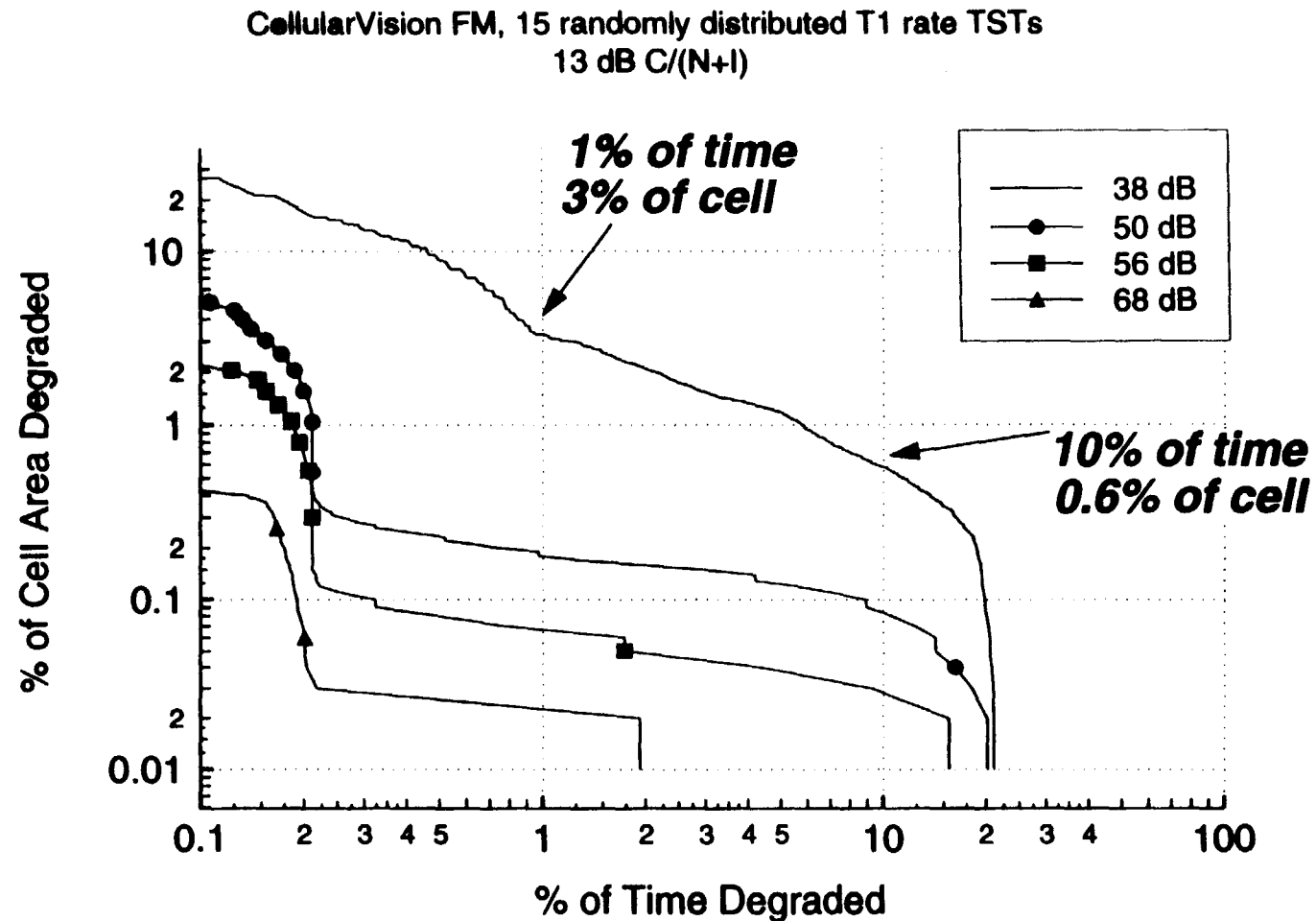# Co-Frequency Sharing of the 28 GHz Band

Availability Computation Road Map

- Use the binomial distribution to determine the probability that exactly X number of simultaneously transmitting FSS uplinks will be located in an LMDS cell
  - FSS traffic clustering near city centers is considered
- Combine Degradation Distributions as weighted by the binomial distribution of the number of simultaneous interferers in an LMDS cell
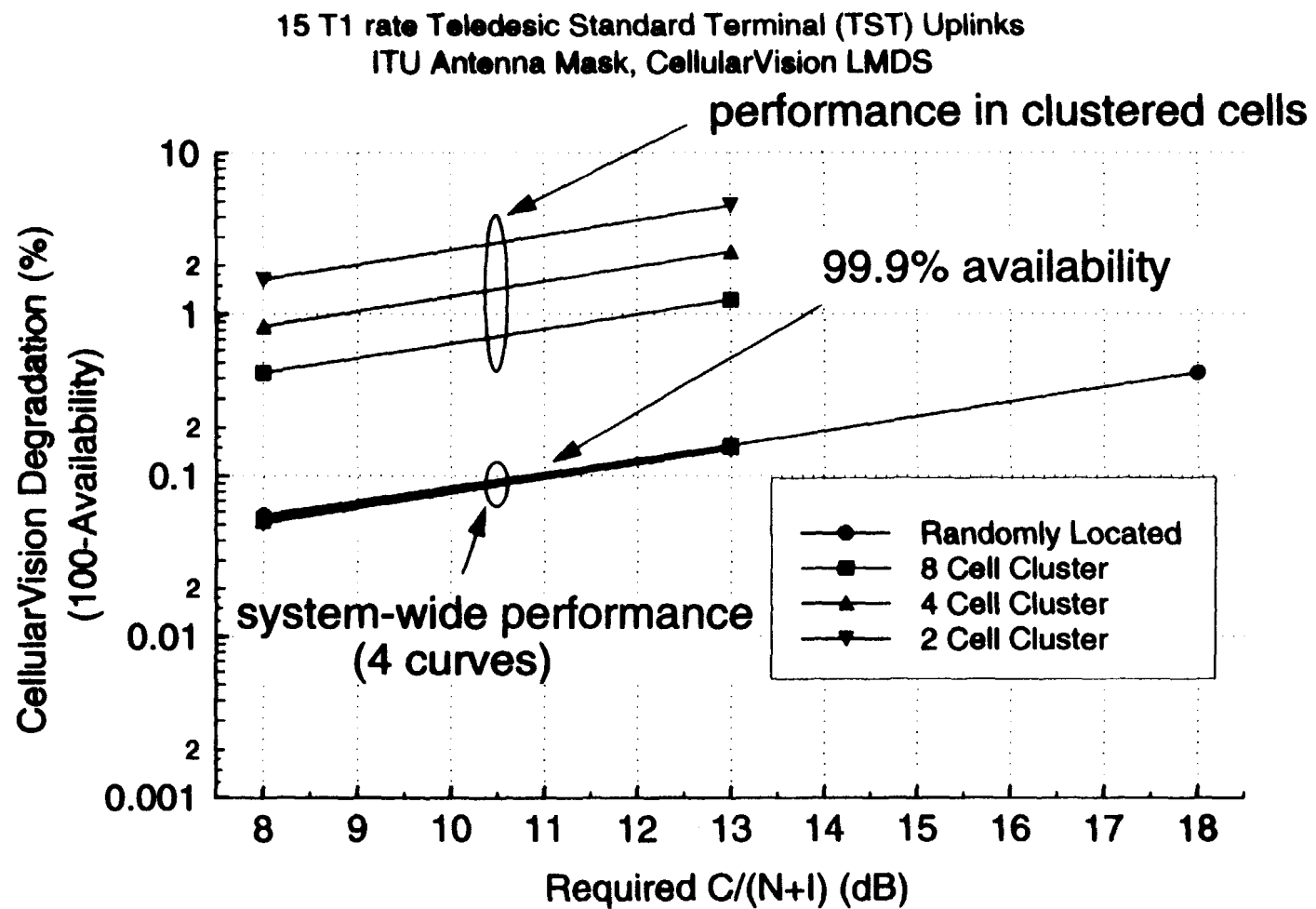- Integrate the combined Degradation Distribution to obtain LMDS availability

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Co-Frequency Sharing of the 28 GHz Band
Combined Degradation Distribution

CellularVision FM, 15 randomly distributed T1 rate TSTs
13 dB C/(N+I)

Legend:
- 38 dB
- 50 dB
- 56 dB
- 68 dB

1% of time
3% of cell

10% of time
0.6% of cell

Y-axis: % of Cell Area Degraded
X-axis: % of Time Degraded

Bellcore

Co-Frequency Sharing of the 28 GHz Band
Availability

15 T1 rate Teledesic Standard Terminal (TST) Uplinks
ITU Antenna Mask, CellularVision LMDS

performance in clustered cells

99.9% availability

system-wide performance
(4 curves)

Legend:
- Randomly Located
- 8 Cell Cluster
- 4 Cell Cluster
- 2 Cell Cluster

CellularVision Degradation (%)
(100-Availability)

Required C/(N+I) (dB)

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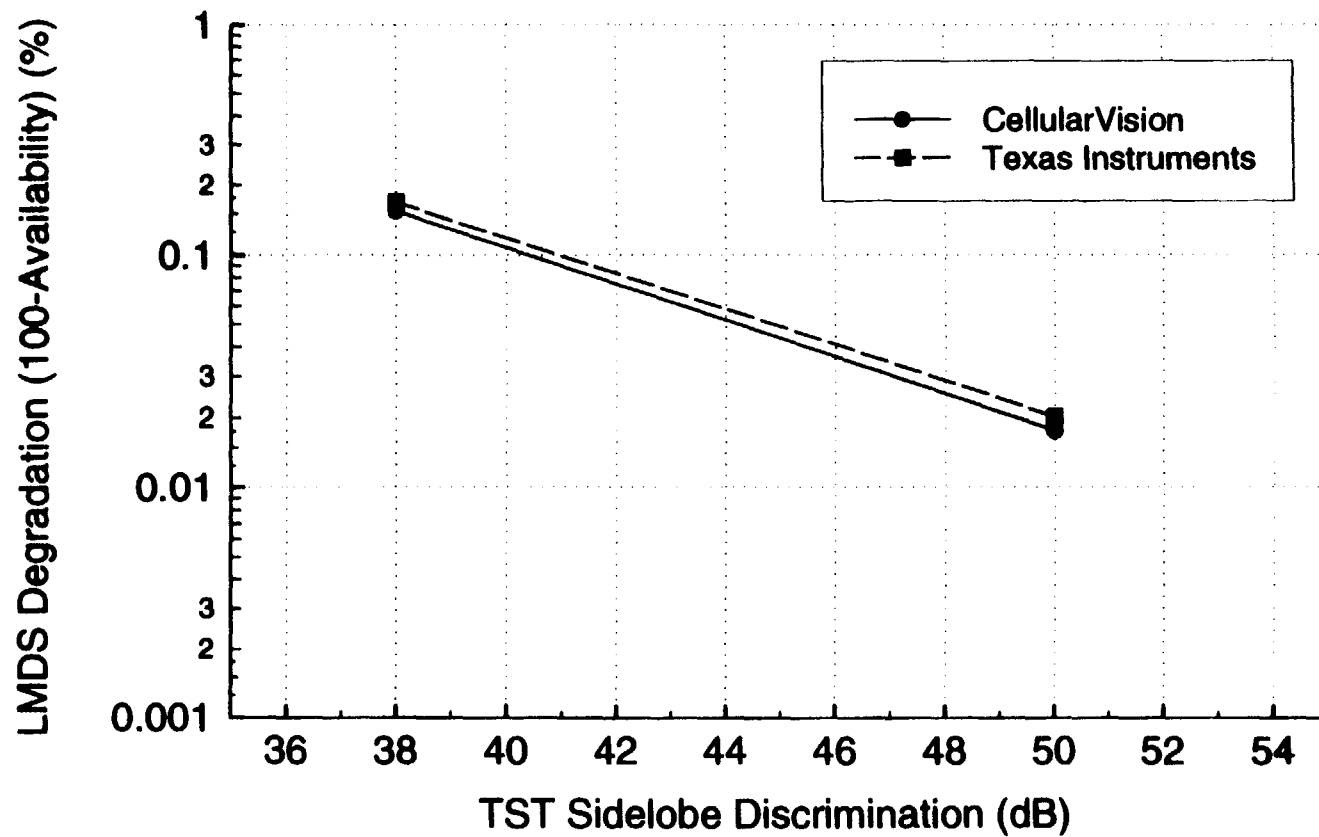
Co-Frequency Sharing of the 28 GHz Band
Availability

15 Randomly Located T1 rate Teledesic Standard Terminal (TST) Uplinks
13 dB C/(N+I)

Bellcore

Co-Frequency Sharing of the 28 GHz Band
Availability - Conservative Assumptions

- **Free Space Propagation** - blockage from trees and buildings will reduce the interference at some locations resulting in increased availability

- **99.9% heavy rain 1% of the time** - the FSS uplinks transmit at full power only under heavy rain conditions; these availability calculations assume full FSS uplink power ten times more often than actual

- **LMDS Antenna** - LMDS subscriber antenna mask used; the real pattern will often have some additional discrimination in the direction of an interfering FSS uplink, reducing the interference and increasing the availability

Co-Frequency Sharing of the 28 GHz Band
Availability - Conservative Assumptions

- **FSS Uplink Antenna** - ITU antenna mask used; the real antenna pattern will often have some additional discrimination in the direction of LMDS receivers, reducing the interference and increasing the availability

- **Satellite Capacity** - availability calculations assume 15 simultaneous T1 rate TST uplinks in a 53 km x 53 km square area; the actual number of simultaneously active terminals will almost always be less than the maximum

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Co-Frequency Sharing of the 28 GHz Band

Availability - Conservative Assumptions

- **Full Spectrum Availability** - availability is defined as the availability of the *entire* portion of the frequency band shared with the FSS uplink system; perceived availability will be higher due to statistical use of different portions of the frequency band; FSS/LMDS Spectrum Protocol can be used to direct interference to certain portions of the band

- **Interference Spectral Density of Narrowband Interferers** - upper bound of peak spectral density is used to compute interference; difference between upper and lower bound can be as large as 23.6 dB (16 kbps TST into 52 Mbps Texas Instruments LMDS)

Availability - Conservative Assumptions

- **Polarization** - statistically, polarization mismatch does occur, leading to a decrease in interference and an increase in availability; polarization mismatch not included in the calculations

  - **Cumulative Effect** - it is conservatively estimated that 60-90% (60-80% for wider bandwidth interferers) of all interference cases computed here will be mitigated by the real-world factors associated with the conservative assumptions
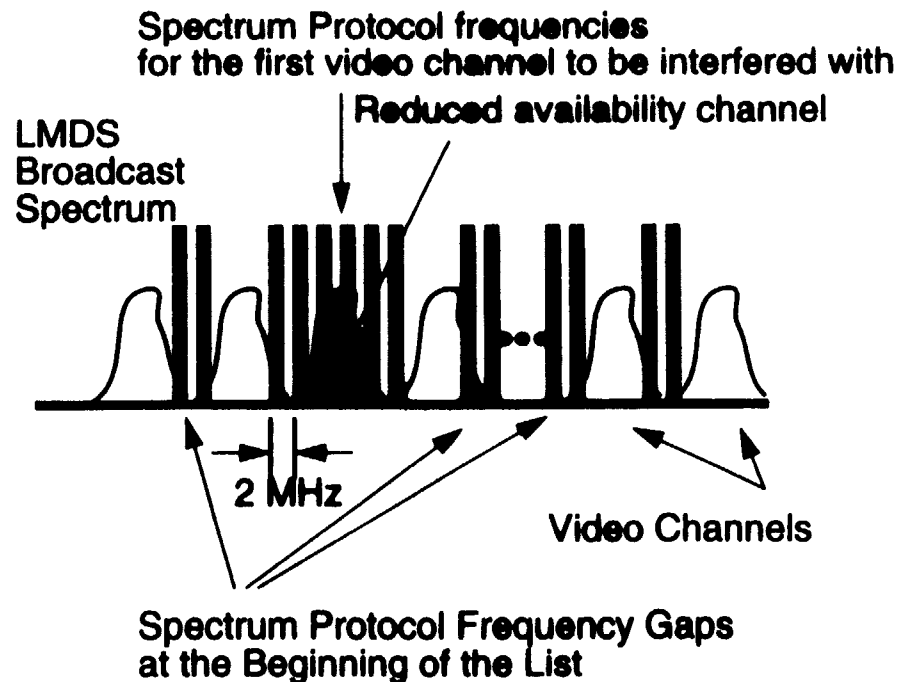
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Co-Frequency Sharing of the 28 GHz Band
FSS/LMDS Spectrum Protocol

- FSS uplink channel selection guidelines
  - Transmit outside the shared portion of the band, if possible
  - Traverse an ordered frequency list, choosing the first available frequency
    - Frequency gaps listed first
    - Frequency blocks corresponding to LMDS channels listed next
  - Different frequency blocks near the beginning of the list in each LMDS cell
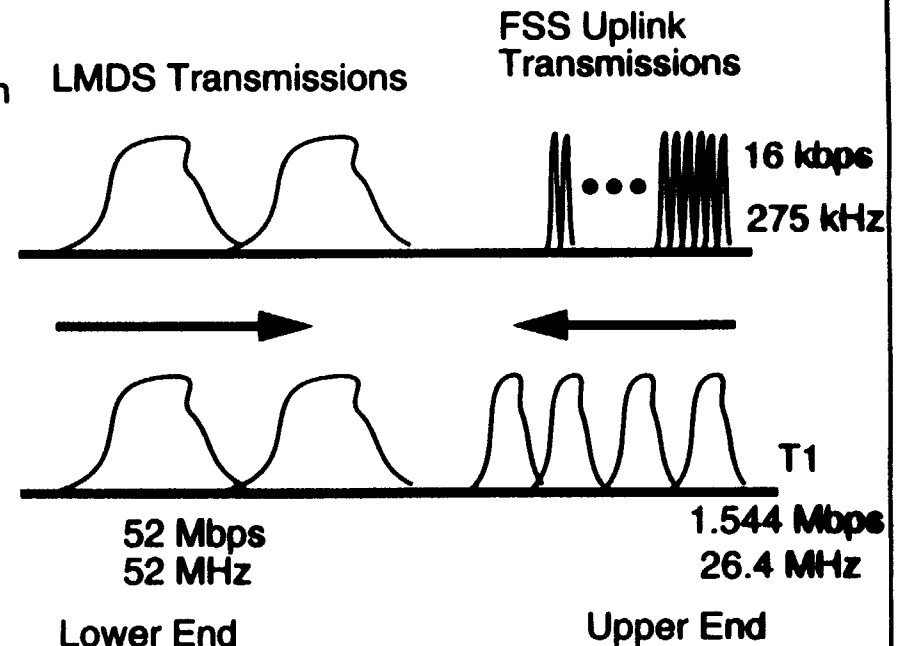
Co-Frequency Sharing of the 28 GHz Band
FSS/LMDS Spectrum Protocol

Broadcast LMDS

Spectrum Protocol frequencies
for the first video channel to be interfered with

Reduced availability channel

LMDS
Broadcast
Spectrum

2 MHz

Video Channels

Spectrum Protocol Frequency Gaps
at the Beginning of the List

Protocol example in a single LMDS cell

Multiple Access LMDS

FSS Uplink
Transmissions

LMDS Transmissions

16 kbps

275 kHz

52 Mbps
52 MHz

T1

1.544 Mbps
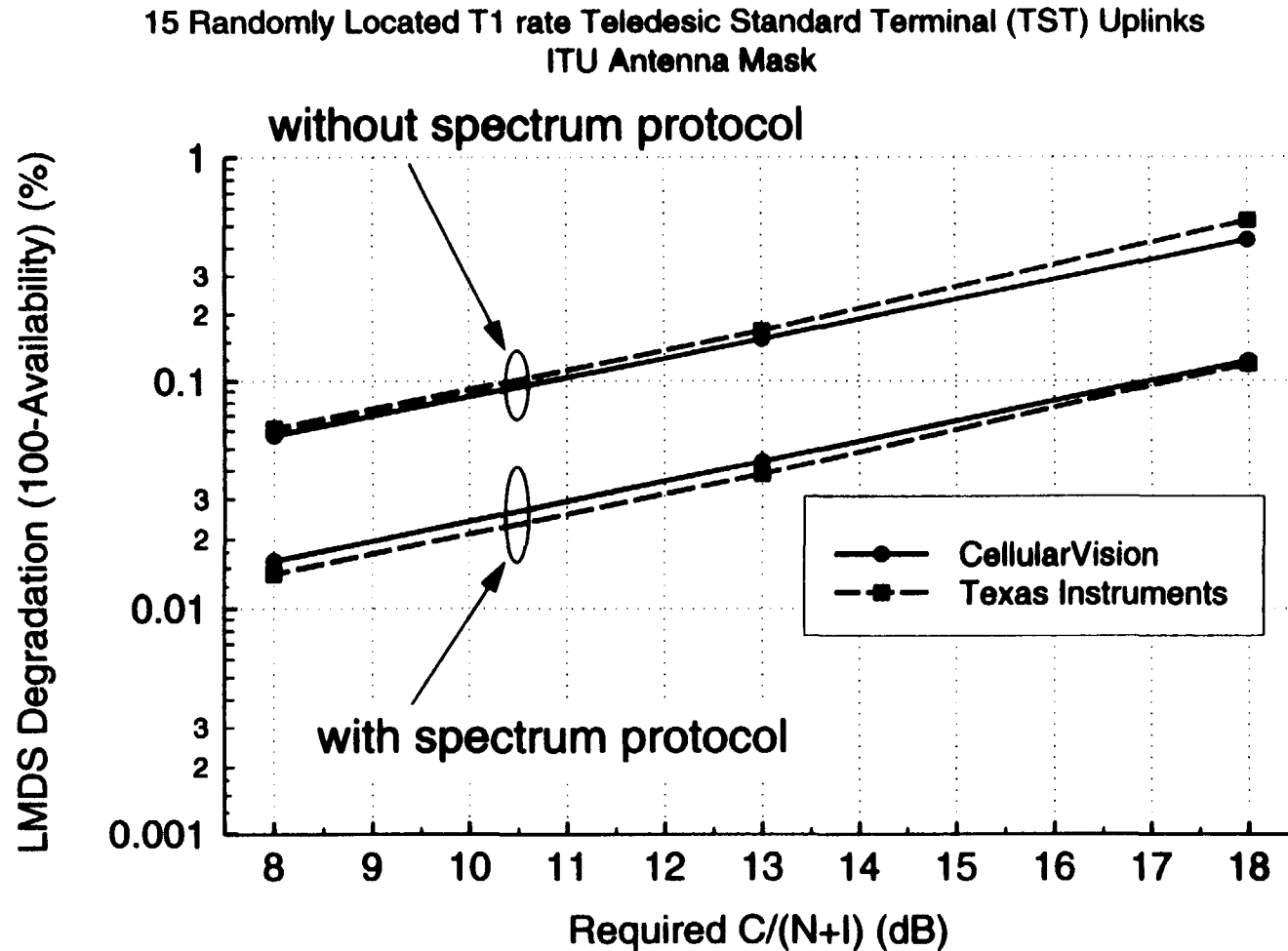26.4 MHz

Lower End

Upper End

"Channel packing"

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Co-Frequency Sharing of the 28 GHz Band
FSS/LMDS Spectrum Protocol

- Ordered frequency list (different in each cell) provided by LMDS service provider based on geographic location of FSS uplink
- Entire spectrum available everywhere for FSS transmissions
  - NOT band segmentation
- No capacity or availability degradation for FSS system
- LMDS system availability computed for shared bandwidth excluding a single reduced availability LMDS channel
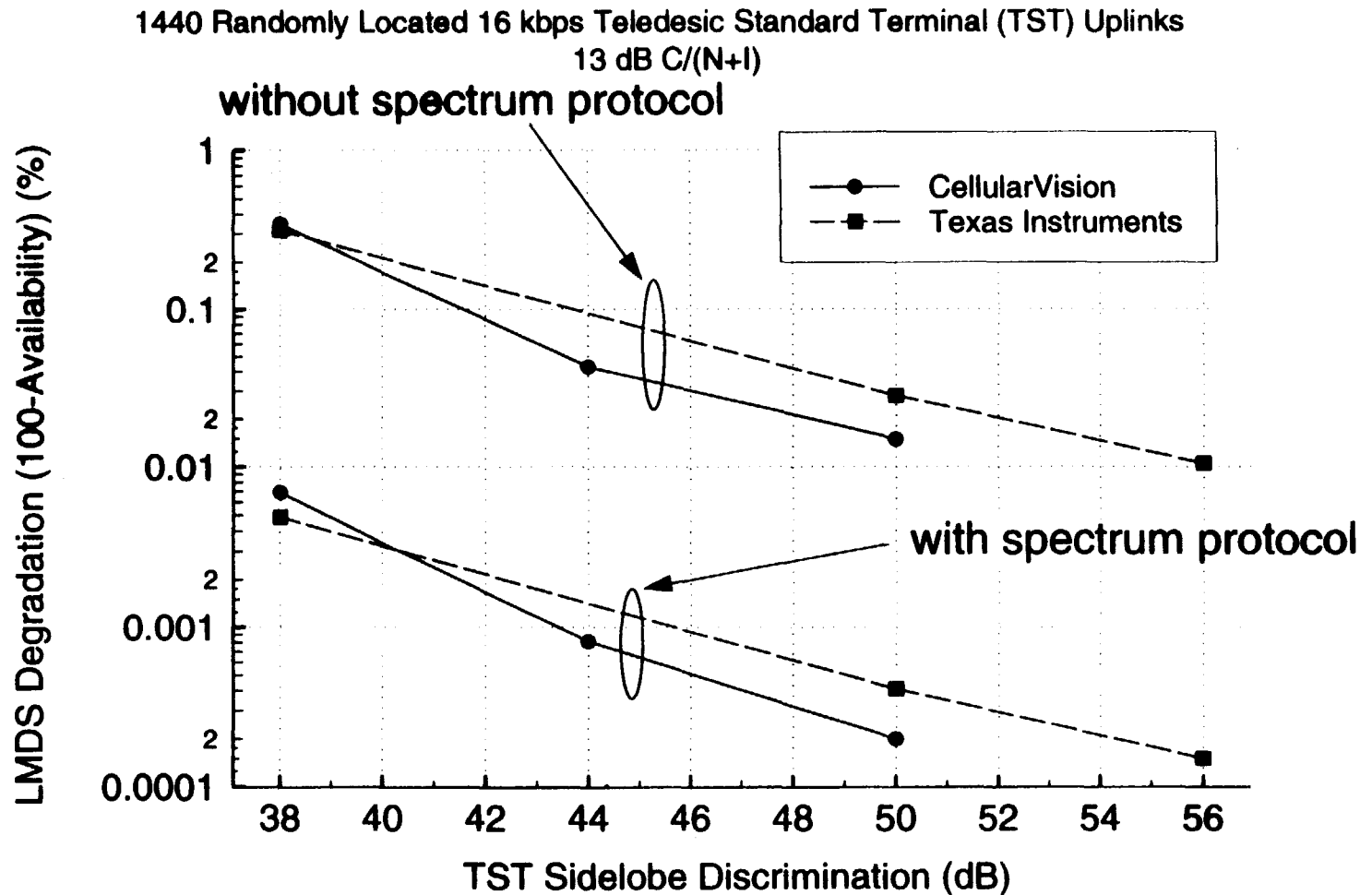
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Co-Frequency Sharing of the 28 GHz Band
Availability with FSS/LMDS Spectrum Protocol

15 Randomly Located T1 rate Teledesic Standard Terminal (TST) Uplinks
ITU Antenna Mask

Co-Frequency Sharing of the 28 GHz Band
Availability with FSS/LMDS Spectrum Protocol

1440 Randomly Located 16 kbps Teledesic Standard Terminal (TST) Uplinks
13 dB C/(N+I)

without spectrum protocol

with spectrum protocol

CellularVision
Texas Instruments

LMDS Degradation (100-Availability) (%)

TST Sidelobe Discrimination (dB)

Co-Frequency Sharing of the 28 GHz Band
FSS/LMDS Spectrum Protocol

	LMDS	FSS
Benefits	• Full 1 GHz per service provider • >99.9% availability in shared spectrum at C/(N+I) of 13 dB • Controlled spectral location of interference in each cell • Immediate deployment possible	• Full satellite bandwidth available everywhere (NO capacity reduction) • Operation on frequencies specified in satellite system design • Minimal impact on system design
Challenges	• Determination of ordered frequency list for maximum availability • Reduced availability in a single channel in shared spectrum • Ordered frequency lists must be provided to FSS operators in a timely manner • Specific isolated cases of repeated interference must be dealt with	• Ordered frequency list information must be obtained from LMDS system operator • Transportability of Earth terminals limited without updating ordered frequency list • Additional signalling traffic on network due to additional database access (depends on implementation)

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Co-Frequency Sharing of the 28 GHz Band
Other Topics Covered in the Report

- Cell overreach - interference from FSS uplinks in adjacent LMDS cells does not invalidate analysis

- Geometric analysis of specular reflections - the presence of specular reflections does not decrease LMDS system availability

- CDMA - the use of orthogonal CDMA on either FSS or LMDS systems improves co-frequency sharing

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Co-Frequency Sharing of the 28 GHz Band
Summary and Conclusion

- NRMC deployment descriptions
- Slightly modified LMDS systems
- Methodology for calculating LMDS system availability
- FSS/LMDS Spectrum Protocol

- *FSS and LMDS can share the 27.5-29.5 GHz frequency band with 99.9% availability for both services without affecting FSS system capacity*

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